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Cost–benefit analysis and immunization programmes in developing countries*

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Cost–benefit analysis of health programmes shows whether a particular investment is economically justified. Existing studies of immunization indicate high rates of return, suggesting that the World Health Organization's Expanded Programme on Immunization makes a real contribution to economic development.

Modifications to cost–benefit methods are illustrated which take account of more appropriate methods of valuing increases in life expectancy and which more accurately reflect costs in developing countries. It is shown that existing studies probably underestimate the benefits of immunization.

In 1976, the World Health Organization (WHO) adopted as its main social target "... the attainment by all the citizens of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life ...".[a] One of the strategies for attaining this target is to provide immunization services for all of the world's children by 1990. This is the goal of the WHO Expanded Programme on Immunization.[b] Substantial increases in investment are required to provide universal immunization services. This paper illustrates how, using the approach of costs and benefits, such investments may be analysed to see whether they are in fact worth while.

The cost–benefit approach to health-sector planning in developing countries is briefly reviewed, then the specific categories of costs and benefits in immunization programmes are outlined. Results from a number of economic studies of immunization programmes are presented, and possible improvements to the technique for future immunization appraisal are advocated.

WHY COST–BENEFIT ANALYSIS?

Cost–benefit analysis (CBA) is a method for determining whether the value of a project or programme is greater than the cost of the resource inputs it uses: the greater the excess of benefits over costs, the more worthwhile the programme. The attractiveness of CBA lies in its claim to provide information pertinent to the major planning choices—what to do and how much to do—in an explicit and consistent fashion.

CBA of health investments in developing countries involves tackling two types of problem: the difficulty in developing countries of conducting an economic appraisal in situations where the price mechanism often gives a distorted measure of true scarcity, and the difficulty in the health sector of finding a simple and acceptable index of performance or output from health services. The first type of problem can be approached by introducing correction factors for the actual market prices prevailing in developing countries. These are necessary (*a*) to ensure the economic efficiency of the project, which involves correcting input and output prices to take account of common types of market distortion in developing countries, and (*b*) to incorporate equity considerations, where governments wish to direct the income distribution benefits of a project towards particular groups.

The difficulty of establishing whether most health services are worth while derives from problems of measuring overall health status and calculating the contributions of health services to changes in that status. Lack of quantifiable outputs has led to economic analyses in the health sector commonly being focused on comparisons of the cost-effectiveness of alternative strategies for attaining a given goal. Although useful, this is far less ambitious than cost–benefit analysis, which seeks to compare the worth of investments toward different goals, both within and outside the health sector.

However, the performance of immunization programmes can be measured, subject to technical considerations of vaccine potency and correct immunization procedure, by the number of children or the proportion of the target population immunized. This

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[b] World Health Assembly resolution WHA30.53.

information, together with disease-specific data on the incidence, mortality, and morbidity rates, and vaccine effectiveness, allows the estimation of deaths and morbidity prevented by immunization, and the cost of achieving these reductions. Such reductions in morbidity and mortality, and the consequent drop in the demand for treatment, constitute the principal benefits of immunization; by comparing the value of these with the cost of the programme, it can be ascertained whether the programme is economically justified. Although levels of accuracy vary widely, many of the data required for such calculations are easily available.

Although the economic case alone will not determine health priorities, it is possible to conduct formal economic evaluations of immunization programmes. Cost–benefit analysis therefore provides considerably stronger evidence as to the viability of immunization programmes than is available to justify the maintenance or expansion of most other health acitivities.

COST AND BENEFITS OF IMMUNIZATION PROGRAMMES

The basic steps in CBA are the identification, valuation, and summation of the costs and benefits in each year of the project's life.[c] All of the resources of a programme are relevant to its economic appraisal so if an immunization programme uses funds from international agencies and imposes costs (in time or money) on recipients and their families, these, too, should be included in the analysis. "Intangible" items, such as pain, discomfort, and anxiety, should also be identified.

Valuation of the cost and benefit elements is likely to be a problem where (*a*) there are no market prices for the items in question, for example reductions in morbidity, or reduction of anxiety, or (*b*) existing market prices are a misleading indicator of "true" value or social opportunity cost, as with the costs of unskilled labour in many developing countries. The separation of individual cost and benefit items makes it possible to test a range of possible prices for their impact on the project's overall economic viability, and also to incorporate policy decisions, for example on the priority of different social groups affected by the project, as "weights" in the analysis. Thus, if a broadly redistributive policy is being promoted nationally or sectorally, gains to lower income groups or the rural poor would be assigned greater importance than similar gains in non-priority groups.

Summing the costs and benefits over a number of years involves discounting those items occurring in the future at a rate that represents society's preference for present, rather than future, income. The higher the rate of discount, the lower the present value of any future cost or benefit. There is no obvious "correct" discount rate and, although it is common practice to use a higher rate for project appraisal in developing countries, an equally good case can be made for using a low discount rate, which means putting a relatively high value on the economic welfare of future generations. The rates actually used in health programme appraisals vary from zero to 18%.

Costs of immunization

The principal components of immunization programme costs are the wages of the immunizing and supervisory staff, and transport costs, the cost of vaccines in most cases being a small proportion of the total. Costs also occur in the form of time sacrificed to attend clinics; and in the small number of adverse reactions to vaccines. Unit costs—costs per fully immunized infant—vary considerably within programmes, reflecting differences in the accessibility of the immunization centres. Studies of immunization costs in the Philippines Expanded Programme on Immunization show a range from about US $1.50 to US $6.00 per infant in existing priority areas for infant DPT and BCG vaccinations (A. L. Creese, unpublished data, 1978) and estimates for the cost of measles immunization in Zambia show a range from about US $1.30 to over US $12.00 per infant (J. M. Ponnighaus, unpublished data, 1978). WHO estimates a global average cost per fully immunized child of approximately US $3.00.

High unit costs in thinly populated rural areas may make universal immunization against a single disease uneconomic. But since the vaccine itself represents a small part of the total cost, immunization against several diseases at the same time should give a good economic yield for the small additional expense.

Benefits of immunization

There are five main categories of gain from immunization: (1) savings in treatment costs following reduced incidence of disease; (2) reductions in mortality; (3) reductions in morbidity; (4) avoidance of "intangible" costs, e.g., suffering, to children and their families; (5) "external" or spill-over benefits.

[c] Formally, the decision criterion in CBA is that Net Present Value (NPV) should be positive; the higher the NPV, the higher the priority of a particular investment.

$$\text{NPV} = \sum_{n} \frac{(B_n - C_n)}{(1 + r)^n}$$

where NPV = net present value, r = rate of discount (social preference rate), B = benefits, C = costs, and n = number of years $(0,1 \ldots n)$.

Savings in treatment costs. Where treatment is routinely provided for infectious diseases, there will be a release of medical resources following a reduction in the incidence of a major disease. This is likely to take the form of easier access to care rather than cash savings, but the release of hospital beds and the reduction of outpatient waiting-time are real benefits of disease control. Private savings to patients and their families are also likely. An estimate, for 1953 in the USA, of the economic gain resulting from the reduction in treatment required for poliomyelitis was in the region of US $21 million (*1*), and for the USSR it is estimated that the saving in the use of immunoglobulin alone equalled the costs of the national measles immunization programme (*2*).

Using the treatment cost criterion on its own as a basis for estimating the cost and benefit "balance point" for immunization services, Grab & Cvejtanović (*3*) show that:

$$Ct = 10\,000 \,.\, (Cv/Ev) \,.\, (1/i)$$

where Ct = cost of treating one case, Cv = cost of immunizing one individual, Ev = vaccine effectiveness, and i = incidence rate (per 10 000 at risk). But there are two limitations of this approach. First, in any economy, treatment costs are unlikely to constitute the major proportion of the total social cost of a disease where death occurs on a large scale in early life. Treatment costs for diseases of early infancy in the USA are estimated to account for less than 2% of the total economic cost, and to be about 25% for all infective and parasitic diseases, the remainder being economic losses related to morbidity and premature mortality (*4*). Benefits in the form of saved treatment costs alone, therefore, give an unsystematic underestimate of the total cost of illness, and are an inadequate basis for rejecting immunization programmes on economic grounds.

Secondly, in developing countries treatment in the "modern" health sector is likely to be inaccessible to large numbers of people, because of the paucity of basic health services. Calculations of benefits in terms of avoided treatment are based on existing patterns of utilization, which largely reflect the availability of services. Since provision is low, treatment benefits will appear low—a classic example of a low-level equilibrium trap. Indeed, it is the absence of treatment facilities that gives cogency to the medical argument for preventive measures being taken where simple and effective techniques exist.

Benefits from reduced mortality. Valuing a life-saving activity is the most difficult and important part of CBA in health planning. The difficulties arise in part because thinking about the value of human life involves unpleasant and unfamiliar decisions, and in part because the individual and society may be expected to have different views about the value of life. These difficulties are reflected in the variety of approaches to economic valuation of human life.

The importance of obtaining such valuations derives from the fact that the major impact of many public health undertakings, particularly in developing countries, is on the expected duration of life, and this is certainly a characteristic of immunization programmes. To omit the benefits in terms of lives saved or prolonged is, therefore, to neglect the primary output of the programme.

If the value of a human life in developing countries were regarded as negative (as Enke (*5*), advocating investments in birth control, has argued) then there might appear to be no economic justification for life-saving health programmes or for those health programmes that simply relieve morbidity rather than save life. But this is an extreme view, based on a questionable approach to the valuation of human life which naïvely equates economic welfare with gross national product. Even in circumstances where a positive social value is placed on the prevention of a birth (that is, where there is an economic justification for family planning), this is not incompatible with putting a positive value on the lives of all children born. Indeed, it can be argued that where fertile couples can exercise their free choice, a reduction in infant mortality is essential for effective family planning programmes. Consequently, if life may be considered to have a positive (but finite) value, then life-saving can be used as an indicator of priority among health investments, and indeed among a wide range of public sector investments.

There are three broad approaches to the valuation of life. The human capital method is based on expected lifetime earnings, and therefore gives a lower value to life where formal employment opportunites and wages are low, as in developing countries. The advantage of this approach lies in its feasibility: it is easy to obtain the data required. The disadvantage is that it contradicts experience: most societies place a positive value on the lives of even their unproductive members. Despite its limitations, variants of this technique are used in each of the CBA studies outlined in the next section.

A second approach is to ask individuals their willingness to pay for reductions in the risk of death (*6*). In the case of infant immunization, this would be a measure of parents' willingness to make sacrifices to have their children immunized, and would relate both to the level of information about the disease and the immunization, and to income. Minimum estimates of the value of these services can be obtained by measuring travel costs, time taken off normal activity and so on, in arranging for a child to be immunized. This approach, unlike the human capital method, invariably gives a positive value to life saving and

recognizes the benefit of immunization to individuals and their families. A theoretical comparison of the two approaches shows that this method of valuing life is likely to give a higher figure than the human capital method (*7*). In addition, a recent empirical study has shown that individuals put very high values on marginal changes in their own and their families' longevity. In this study, a mean value of about one-third of the individual's annual income was recorded for much smaller changes in survival probability than would be likely from, for example, a poliomyelitis immunization programme in a developing country (*8*).

The third alternative is to use actual values for human life, derived from past decisions. For example, if an immunization programme costs an average of US $3.00 per child and gives a 10% reduction in the probability of death over a 10-year period, then a benefit value of about US $0.60 a year per immunized child is necessary to make this a worthwhile investment.[d] If the programme is not undertaken the implicit value put on reducing the probability of death is less than US $0.60 per year. If the programme is implemented a value of at least US $0.60 a year for the increased chance of survival is demonstrated. In practice this rather circular approach is beset by inconsistencies in the revealed preferences of decision makers, though it has the advantage of showing that decisions about the value of human life are implicit in routine decisions about the nature and scale of provision of health services.

Thus, though there is substantial agreement that life saving from immunization programmes should be positively valued as a benefit, there are differences in the approaches taken to the valuation of life in CBA. The relatively low costs of immunization, the high incidence rates for diseases such as measles, and the very high effectiveness of immunization, together with the likelihood of some saving in treatment costs, mean that the actual value that has to be placed on saving an individual life can be relatively low—less than US $1.00 a year—for immunization to be a worthwhile investment.

Benefits from reduced morbidity. Sick children are sometimes considered to be an economic cost only if they make treatment demands on health services: reducing the numbers of sick, untreated children would therefore not constitute an economic gain. This approach understates the economic importance of infant morbidity, however. Morbidity may be in the form of a handicap (e.g., blindness) that affects the child's activity throughout life, and reduction in the risk of handicap should be valued in the same way as reductions in the risk of premature mortality, though this is seldom done in CBA. In addition, the child's family may sacrifice work time and income as a result of morbidity: these sums are therefore benefits resulting from immunization and should be enumerated.

Avoidance of intangible costs. Health programmes characteristically have effects which, though important, are extremely difficult to measure and to value. Benefits such as reduced anxiety, pain, or discomfort are typical examples: these are desirable "outputs" of the health system, but they are not readily comparable with other outputs such as increased productivity. Attempts have been made to attach notional values to such intangibles, such as the US $2000 per annum "cost" of the stigma of syphilis used in a North American study (*9*), but in most studies the intangible benefits are described but not valued. This practice contributes to the understatement of programme benefits and reduces the measured benefit/cost ratio. In the context of developing countries, where treatment savings and measured productivity gains are also likely to be low, omission of intangible benefits compounds the apparent economic unattractiveness of many health programmes.

External benefits of immunization programmes. Other individuals and agencies benefit from immunization in addition to the vaccinated children. Some of these spill-over benefits derive from the general reduction in risk of infection, which gives to all those at risk some part of the benefits enumerated above, and which should be considered as an economic gain.

Other external benefits stem from the institutional changes that accompany the increased accessibility of effective health care, and in many developing countries a programme such as WHO's Expanded Programme on Immunization offers benefits which result in strengthening both the managerial capacities of national health services and the participation of communities in national health initiatives.

Although immunizations are among the easiest of health services to deliver, the organization of a national programme nevertheless requires substantial managerial skills. The task of providing health workers who administer immunizations with a continuous supply of potent vaccines by ensuring that they are ordered in time and are stored and transported under appropriate temperature conditions is one example. Such managerial skills are generally scarce in developing countries, and a recognized cost of initiating immunization programmes in such areas is the investment required to strengthen them.

Such an investment will not only permit the utilization of currently available vaccines, but will also establish the infrastructure capable of administering new vaccines as they become available. Not only will it be possible to employ the new vaccines at less cost,

[d] Assuming a constant annual benefit of US $0.60 and a discount rate of 15%.

using the established delivery system in whole or in part, it will be possible to employ them without appreciable delays. In addition, the investment in developing good managers for immunization programmes should also improve the management of other health programmes, not only because the skills are the same, but also because the immunization managers themselves will often share responsibilities for other programmes.

The provision of immunization services may also encourage community utilization of other health services. The impact of immunization on reducing the incidence of diseases such as measles and poliomyelitis can be dramatic and, particularly in cultures where there may be limited acceptance of the treatment services and advice offered by professional health workers, the initiation of an effective immunization programme can serve to improve the utilization of other services whose benefits are less immediate.

Recognizing that there is some underestimation of costs as well as of benefits, the considerations described above nevertheless indicate that, if the approaches to CBA commonly utilized in the health sector are applied to immunization programmes in developing countries, a substantial underestimation of net worth will be likely. Studies using these approaches may therefore be considered more reliable in identifying when programmes are worthwhile than when they are not, and this is the case with the studies described below. Possibilities for improving the approach to CBA in the health sector in general, as well as to immunization programmes in particular, are presented in the last section of this article.

IMMUNIZATION PROGRAMMES: DO THE BENEFITS EXCEED THE COSTS?

In spite of systematic underestimation of the benefits of immunization and notwithstanding considerable differences in the detailed procedures in the CBA of immunization programmes, there is general evidence of positive—and often very high—returns on such investments.

Studies of measles immunization programmes in developed countries all show high net benefits. In the USSR, the programme was justified economically by part of the treatment savings alone, suggesting very large total gains (*2*). In Sweden over a 30-year period, the returns on measles immunization are estimated at three times total programme costs (J. Jonasson, unpublished data, 1971). In Finland and the USA, measles programmes have been shown to have high net benefits (*10*), with a benefit/cost ratio in the USA of approximately 10:1 (*11*). Each of these studies uses a simple human capital model projecting expected working years saved, and each uses a low (0–4%) rate of discount. For tuberculosis in Britain, however, in 1976 Stilwell (*12*) showed that immunization was no longer economic, the low risk of infection making the cost of preventing one case very high—about UK £5500 (US $11 000).

For southern Zambia, J. M. Ponnighaus (unpublished data, 1978) has shown that in urban areas the benefits exceed the programme costs by a factor of four, and this on the conservative assumption that there is no economic value to the saving of infant lives. Attaching a positive value to each infant life saved would justify the expansion of the programme to the rural population, though in the very thinly populated areas the programme's costs would still exceed its estimated benefits.

For poliomyelitis, B. Lindholm (unpublished data) has shown programme costs in Sweden over 21 years to be less than one-sixth of total benefits, indicating a very high rate of socioeconomic return. In Indonesia, an economic appraisal over a five-year period of an immunization programme against diphtheria, pertussis, tetanus, and tuberculosis showed that the cost of preventing an average case was approximately one-third of the cost of treatment (*13*).

Ponnighaus's study also illustrates clearly how the giving of priority to rural populations could make immunization investments appear even more worth while—by weighting the benefits derived from one rural infant's immunization differently from those associated with urban immunizations. This would bring the welfare function in cost–benefit analysis (net present value of an investment) into closer line with the aims of the policy maker whose concern may be to redress inequity in access to health care. The reformulated decision criterion in the cost–benefit analysis would then become the maximizing of net present value subject to a distributional constraint. It is significant that none of the studies reviewed uses a rural-weighted objective, and this appears to be an area in which economic appraisal in the health sector has not kept abreast of developments in other spheres of project appraisal (*14*, *15*).

TOWARDS A BETTER TECHNIQUE FOR THE ECONOMIC APPRAISAL OF IMMUNIZATION PROGRAMMES

As cost–benefit analysis has become internationally applied in public-sector investment appraisal, it has also been modified in a variety of ways to take account of the special circumstances of developing countries (*16*, *17*). We have outlined how existing evidence on the scale of welfare gains from immunization is likely to underestimate the true value of such programmes,

and have identified the need for modifications in cost–benefit practice for the evaluation of health-sector programmes. The changes suggested are modifications to make cost–benefit analysis more cognizant of the particular institutional context of health-care delivery in developing countries, and are not an alteration of the basic technique.

First, and of particular relevance in health programmes, the inadequacies of the human capital approach of life valuation have to be tackled. Expected gains in marketed labour are in any case only one part of the benefits of improved life chances, and in the rural sector of many developing countries these will often appear very low. The value of such benefits is, from a theoretical and practical viewpoint, better measured by the sacrifices people make in order to use health services—the time they take off from their normal activities, the distance they travel, and the monetary costs they incur. The problem of evaluating such time of course remains, but the value of an hour of lost parental time necessary to cover the cost of the programme can be calculated, and health planners can decide on the basis of this figure whether immunization is worth while. Although the value problem is inescapable, there is, as Mishan argues on this particular issue, "... more to be said for rough estimates of the precise concept than precise estimates of economically irrelevant concepts" (*18*).

Second, a consideration of distributional equity is often an important component of development plans, both for the health sector and nationally. Priority is often given, in word or in substance, to the interests of the poor, and particularly the rural poor. Such priority can and should be reflected in cost–benefit studies by a system of weights that discriminate in favour of the priority group by raising the relative value of their benefits, as suggested earlier. For providing services to scattered rural populations where unit costs might increase rapidly, there would be some compensating escalation of benefits if such groups are designated as a priority, and this would ensure that the increasing market price of services for such groups does not restrict provision regardless of recognized need.

Third, from the general viewpoint of economic efficiency, it is widely recognized that distortions in the domestic economy may mean that market prices do not accurately reflect true scarcity. Increasingly, planning offices in developing countries use a standard set of "accounting prices" to correct for these distortions in appraising projects. Such accounting prices should also be used in health-sector planning. The general effect of accounting prices in the appraisal of immunization programmes would be to reduce part of the wages cost and to raise the price of imports, such as vaccines and equipment, used by many countries. Since the latter account for a relatively small proportion of total programme costs, the "shadow-price" of a fully immunized infant would probably be lower than its market price; but there would also be adjustments to the values of benefits from immunization, and the net effect will depend on the particular character of any programme.

RÉSUMÉ

APPLICATION DE L'ANALYSE COÛT/AVANTAGES AUX PROGRAMMES DE VACCINATION DANS LES PAYS EN DÉVELOPPEMENT

L'accroissement de l'investissement en faveur de la vaccination contre les principales maladies infectieuses a des conséquences qui peuvent être appréciées au moyen d'une analyse coût/avantages et d'une comparaison entre le bénéfice retiré d'un programme de vaccination et celui procuré par d'autres investissements dans le domaine de la santé. Le premier terme de cette comparaison est le plus facile à établir car on peut l'exprimer immédiatement par le nombre des enfants vaccinés.

Au chapitre du coût s'inscrivent les frais salariaux et matériels qu'entraînent la fourniture et l'administration des vaccins. Les principaux avantages tiennent au coût des traitements évités et à la réduction de la morbidité et de la mortalité, et il s'y ajoute des bénéfices intangibles tels que l'anxiété et la peine épargnés. Il faut aussi tenir compte des conséquences positives indirectes, comme la baisse du niveau total de risque lié aux maladies évitables grâce à la vaccination et l'amélioration de l'accès à de bonnes prestations sanitaires.

Les résultats d'études menées dans plusieurs pays constituent un bilan positif avec un gain net parfois très élevé, en particulier quand la vaccination vise à protéger simultanément contre plusieurs maladies.

De plus en plus souvent, la technique appliquée à l'analyse coût/avantages est modifiée pour tenir compte de la distorsion que peuvent présenter les prix du marché dans les pays en développement pour des entrées courantes comme la main-d'œuvre non qualifiée et le capital importé, ainsi que pour incorporer dans l'évaluation des considérations d'équité sociale (lorsqu'on souhaite, par exemple, faire bénéficier en priorité d'un programme certains groupes). Ces aspects particuliers devraient être automatiquement pris en compte pour toute évaluation d'un programme sanitaire. En outre, lorsque les vies sauvées font partie des avantages d'un programme, il faut admettre qu'il existe des méthodes plus satisfaisantes pour évaluer cet avantage que celle de l'évaluation du capital humain—c'est-à-dire l'estimation du revenu du travail pendant la durée de la vie.

Les études coût/avantages qui ont été faites montrent généralement que les programmes de vaccination représentent un investissement valable, en dépit du fait que les méthodes d'estimation du coût et des avantages appliquées tendent à sous-estimer les avantages. Il faudrait donc améliorer ces méthodes pour évaluer avec plus d'exactitude le gain net retiré d'un programme de vaccination sur le plan du bien-être social.

REFERENCES

1. WEISBROD, B. A. *Economics of public health*, Philadelphia, University of Pennsylvania Press, 1961.
2. BURGASOV, P. N. ET AL. The status of measles after five years of mass vaccination in the USSR. *Bulletin of the World Health Organization,* **49**: 571 (1973).
3. GRAB, B. & CVEJTANOVIĆ, B. Simple method for rough determination of the cost-benefit balance point of immunization programmes. *Bulletin of the World Health Organization,* **45**: 536 (1971).
4. RICE, D. P. *Estimating the cost of illness.* Washington, DC, United States Department of Health Education and Welfare 1966 (Health Economics Series, *No. 6*)
5. ENKE, S. The economic aspects of slowing population growth. *Economic journal,* **76**: 44-56 (1966).
6. MOONEY, G. H. *The valuation of human life.* London, Methuen, 1977.
7. CONLEY, B. C. The value of human life in the demand for safety. *American economic review,* **66**: 45-55 (1976).
8. JONES-LEE, M. W. *The value of life.* London, Martin Robertson, 1976.
9. KLARMAN, H. E. Syphilis control programs. In: Dorfman, R., ed., *Measuring benefits of government investments,* Washington, DC, Brookings Institution, 1965.
10. EKBLOM, M. ET AL. *Cost and benefits of measles vaccine in Finland* (1978).
11. WITTE, J. J. & AXNICK, N. W. The benefits from 10 years of measles immunization in the United States. *Public health reports, (Washington),* **90**: 205-207 (1975).
12. STILWELL, J. Benefits and costs of the schools' BCG vaccination programmes. *British medical journal,* **1**: 1002-1004 (1976).
13. BARNUM, H. N. ET AL. Cost-effectiveness of an immunization programme in Indonesia. *Bulletin of the World Health Organization,* **58**: 499-503 (1980).
14. MINISTRY OF OVERSEAS DEVELOPMENT. *Guide to project appraisal in developing countries,* London, Her Majesty's Stationery Office, 1974.
15. CHENERY, H. B. ET AL. *Redistribution with growth.* London, Oxford University Press, 1974.
16. LITTLE, I. M. D. & MIRRLEES, J. *Project appraisal and planning for developing countries.* London, Heinemann, 1974.
17. SQUIRE, L. & VAN DER TAK, H. G. *Economic analysis of projects.* Baltimore, John Hopkins University Press, 1975.
18. MISHAN, E. J. Evaluation of life and limb. *Journal of political economy,* **79**: 4 (1971).